

Teacher Resource and Assessment Book

Exercises Unit 3 – answers

2. Exercise: Gravimetric analysis of chicken soup

Part A

- $n(\text{AgCl}) = \frac{0.246}{143.3} = 1.72 \times 10^{-3} \text{ mole}$
- Amount of NaCl in 20.00 mL aliquot = $1.72 \times 10^{-3} \text{ mole}$
- Amount of NaCl in 250.0 mL stock solution = $1.72 \times 10^{-3} \times \frac{250.0}{20.00}$
 $= 2.15 \times 10^{-2} \text{ mol}$
- Mass NaCl in sample = $2.15 \times 10^{-2} \times 58.5 \text{ g} = 1.26 \text{ g}$
- Percentage mass NaCl = $\frac{1.26}{14.962} \times 100 = 8.42 \%$

Part B

1.

Measurement	Uncertainty	Relative uncertainty
Mass of soup (14.962 g)	+ - 0.002g	+ - $\frac{0.002}{14.962} = + - 0.00013$
Vol. of stock soln. (250 mL)	+ - 0.2 ml	+ - $\frac{0.2}{250} = + - 0.0008$
Aliquot of stock soln. (20.00mL)	+ - 0.002 mL	+ - $\frac{0.02}{20.00} = + - 0.001$
Mass of precipitate (0.246 g)	+ - 0.002 g	+ - $\frac{0.002}{0.246} = + - 0.00813$

- Total relative uncertainty = + - 0.01006 = + - 0.010
- Relative uncertainty of % NaCl = 0.010 x 8.34 = + - 0.0834

7. Exercise: Titration curves using second hand data.

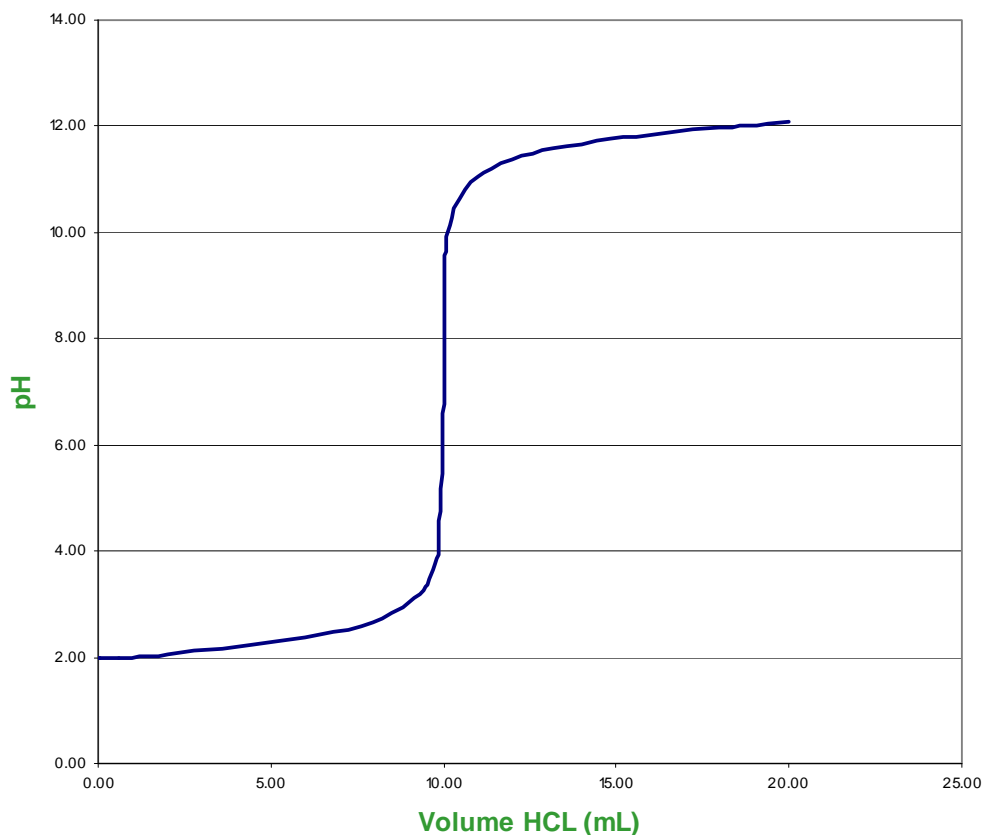
The Heinemann website, <http://www.hi.com.au/chemistry>, contains data table in spreadsheet format that are useful for this exercise.

Note: the spreadsheet for part A is on the 4th edition website but part B is missing. Both parts A and B are on the website for the 3rd edition.

PART A.

1. Down load the data table from the website
2. The graph can be generated from the data table using the chart wizard and selecting the XY scatter chart with lines.

Titration 0.01M HCl with 0.1M NaOH



3. $\text{NaOH (aq)} + \text{HCl(aq)} \leftrightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$
(Editor. Please replace \leftrightarrow with equilibrium arrows as used in the text)

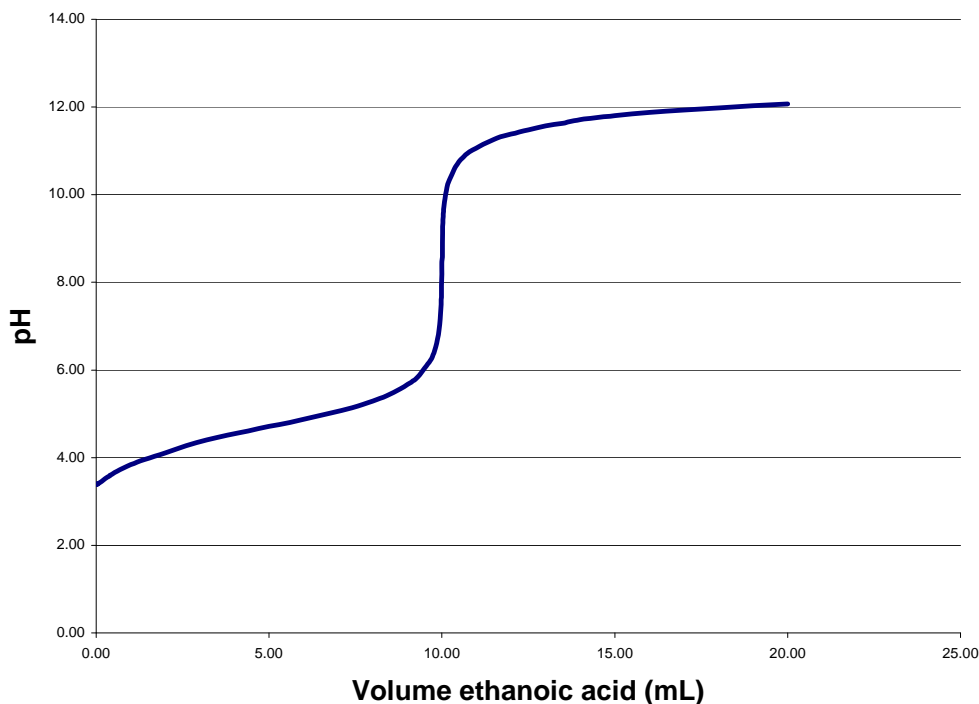
$$\begin{aligned} n(\text{NaOH}) &= n(\text{HCl}) \\ \frac{0.1 \times V}{1000} &= \frac{0.01 \times 100}{1000} \end{aligned}$$

$$V = \frac{0.01 \times 100}{0.1}$$

$$= 10.0 \text{ mL}$$

4. At the equivalence point the curve is close to vertical.
5. a) End point at $\text{pH} \approx 7.0$ this occurs at 10.0 mL
 Phenolphthalein is a suitable indicator because the pH range over which it changes colour includes the equivalence point of the reaction which is at $\text{pH} \approx 7.0$ Phenolphthalein changes colour between a pH of 8.2 and 10.0
- b)
6. The graph will be a mirror image of the first.
7. Down load the data table from the website

Titration 0.01M Ethanoic acid with 0.1M NaOH



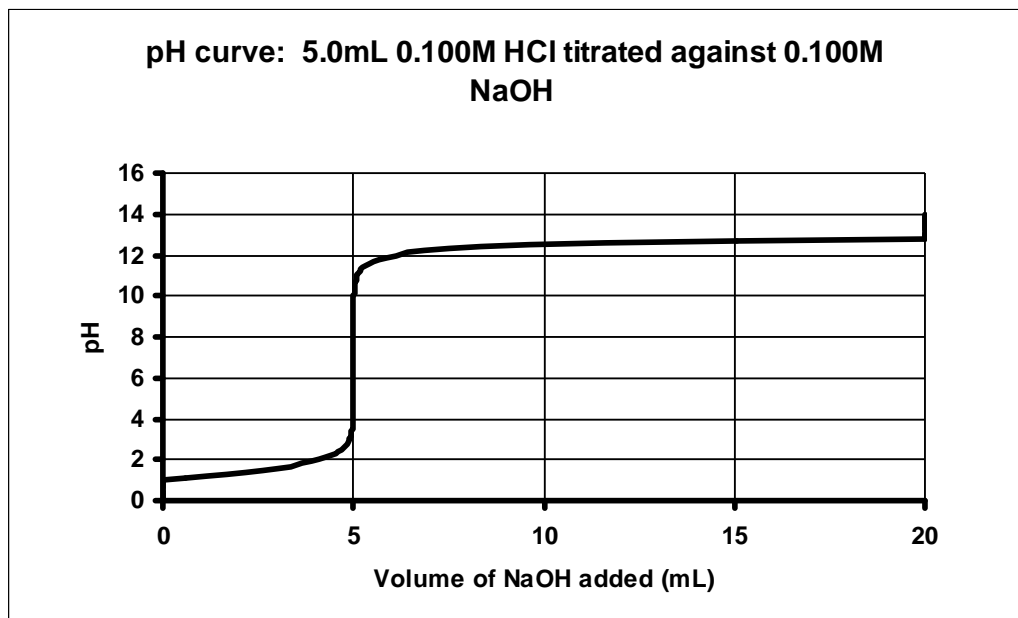
8. The initial pH is lower for the reaction between HCL (aq) and NaOH(aq) The equivalence point is the same for both reactions but there is a greater change in pH near the equivalence point for the reaction between the strong acid and strong base.

9.a The equivalence point occurs between pH =7 and pH =10. Phenolphthalein would be a suitable indicator as it changes colour within this pH range and over a small change in volume of acid. Phenolphthalein changes colour between a pH of 8.2 and 10.0

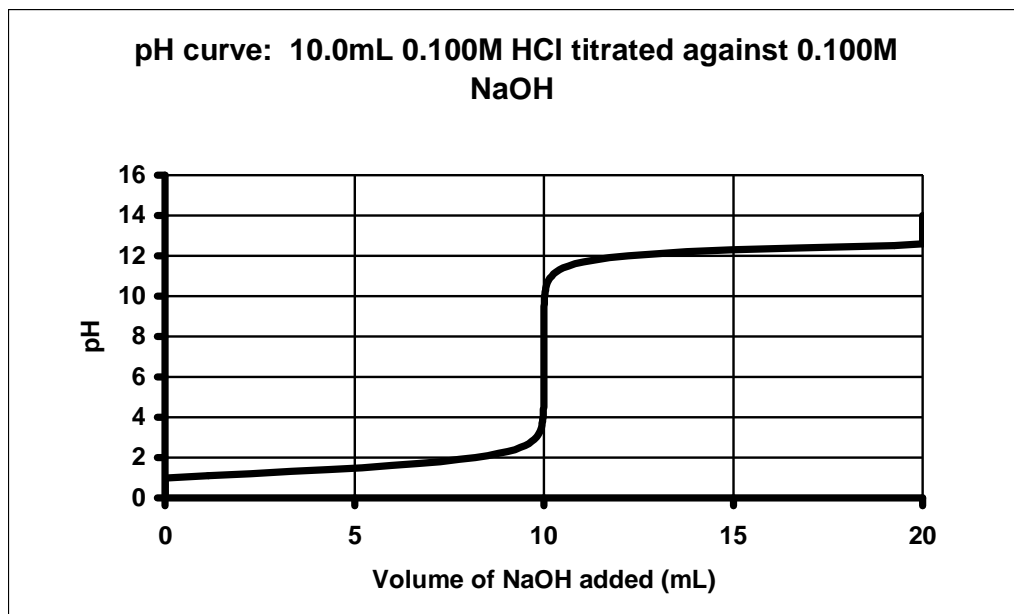
b. Methyl orange would not be a suitable indicator as the pH range over which it changes colour, the end point, is outside the pH at the equivalence point
Methyl orange changes colour between a pH of 3.2 and 4.4

PART B

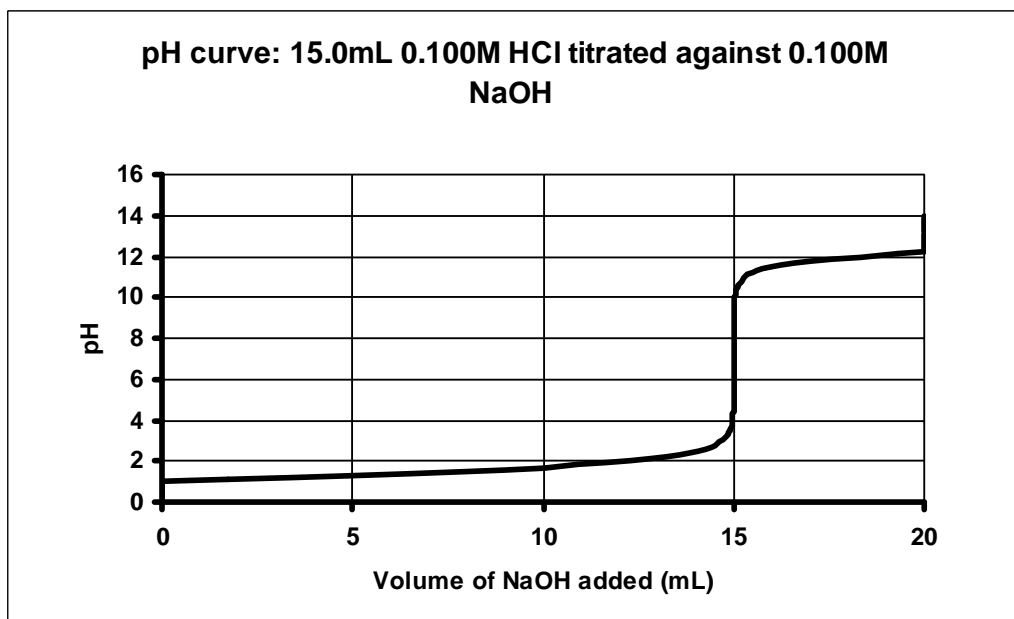
1. a



b.



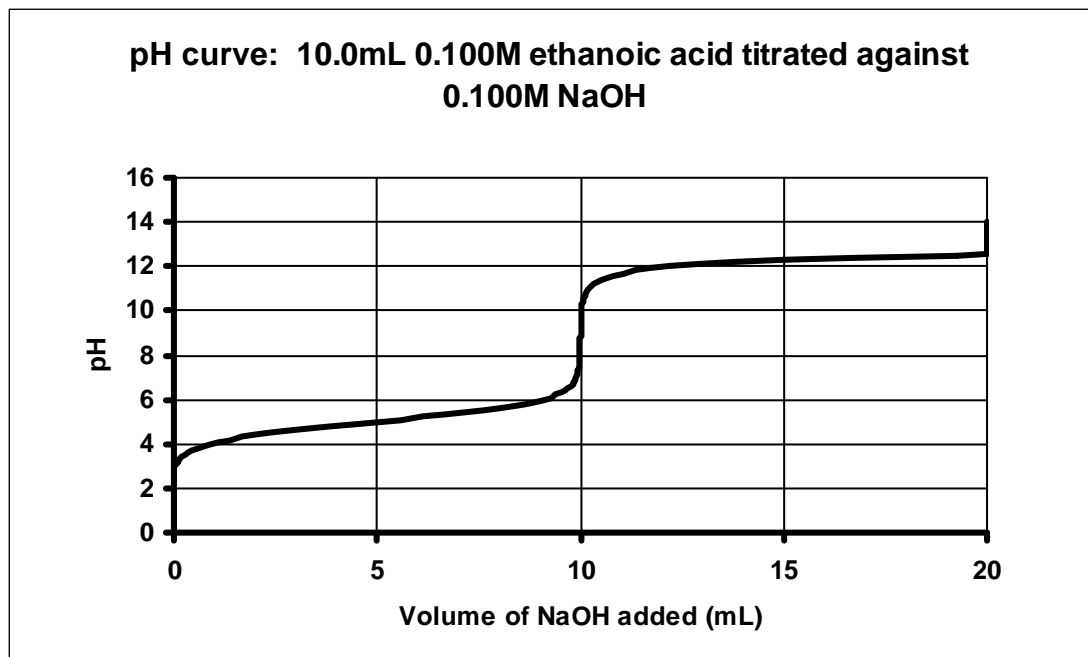
c.



2. At the equivalence point the number of moles of HCl and NaOH are equal. The volume of HCl and hence the number of mole of 0.100M HCl increases in each case. Hence the volume of NaOH required to exactly react with the HCl also increases.
3. In each case pH dramatically changes near the equivalence point from pH = 4 to pH= 10 Both methyl orange and phenolphthalein would be suitable indicators as

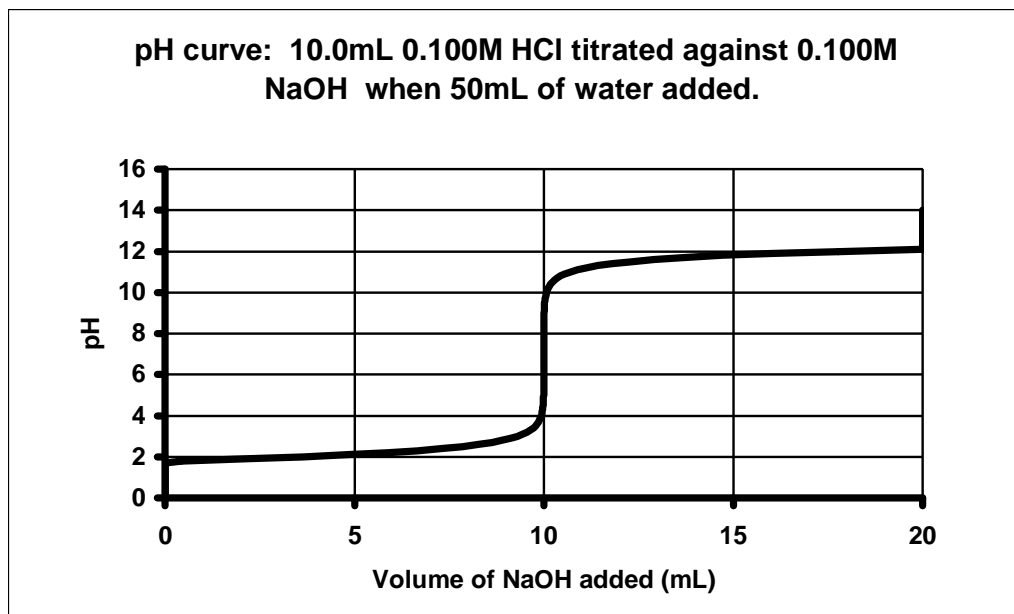
they both change colour within this pH range i.e the end points as indicated by methyl orange and phenolphthalein closely matches the equivalence point.

4



- 5a. The initial pH is lower for the reaction between HCL (aq) and NaOH(aq) The equivalence point is the same for both reactions but there is a greater change in pH near the equivalence point for the reaction between the strong acid, HCl, and strong base, NaOH
- b. The pH at the equivalence point for the reaction between the strong acid and strong base is at pH =7. For the reaction between the weak acid and strong base the equivalence point is at pH = 9
6. The equivalence point occurs between pH =9. Phenolphthalein would be a suitable indicator as it changes colour within this pH range. Methyl orange would not be a suitable indicator as the pH range over which it changes colour, the end point, is outside the pH at the equivalence point

7.



There is no change in the equivalence point. The initial pH is slightly higher and the final pH is slightly lower.

25 Exercise : Designing an analysis of a consumer product

Part A

Questions 1 & 2, Refer to the Experiment; 11 “Analysis of Aspirin Tablets”, for equipment and experimental details.

Question 3. If phenolphthalein indicator is used the end occurs when the first tinge of permanent pink colour appears in the flask.

Question 4.

$$a) 500 \text{ mg aspirin} = \frac{0.500}{180} = 2.78 \times 10^{-3} \text{ mol.}$$

From the equation:

$$n(\text{NaOH}) = n(\text{ aspirin}) = 2.78 \times 10^{-3} \text{ mol.}$$

$$n(\text{NaOH}) = cv$$

$$2.78 \times 10^{-3} = c \times 20 \times 10^{-3}$$

$$c = 0.13 \text{ molL}^{-1}$$

- b) The relative error in the volume of NaOH delivered by the burette is larger for a titre of 5mL than for a titre of 20 mL.

Question 5. Repeating the procedure a number of times and determining the average will improve the reliability.

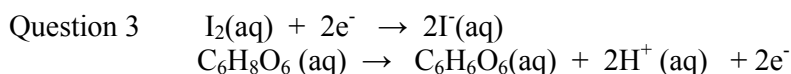
Question 6. Refer to: 11 Experiment “Analysis of Aspirin Tablets”

Question 7

- Because sodium hydroxide absorbs water and carbon dioxide from the atmosphere. Sodium hydroxide is thus not suitable as a primary standard.
- A solution of sodium hydroxide can be standardised by titration against a standardised solution of hydrochloric acid. The hydrochloric acid can be standardised by titration against a solution of sodium carbonate which has been prepared by dissolving and accurately weighed sample of anhydrous sodium carbonate into an accurately measured volume of distilled water.

Part B

Questions 1 & 2 Refer to: 21 Experiment “Analysis of ascorbic acid in vitamin C tablets”



Question 4 Appearance of a permanent blue tinge when the excess iodine reacts with the starch indicator.

Question 5

$$250 \text{ mg ascorbic acid} = \frac{0.250}{176} = 0.00142 \text{ mole}$$

From the equation

$$n(\text{I}_2) = n(\text{C}_6\text{H}_8\text{O}_6) = 0.00142 \text{ mole}$$

$$c(\text{I}_2) = \frac{0.00142}{0.02} = 0.071\text{M}$$

Question 6 A primary standard has a high level of purity, has a known composition and a high molecular mass. A standardised iodine solution may be obtained by titrations against a primary standard such as sodium thiosulfate.

Question 7 Refer to: 11 Experiment “Analysis of Aspirin Tablets”

Part C

Question 1. Refer to: 14 Experiment. Determination of the ethanoic concentration of vinegar

- Question 2
- Rinse the pipette with diluted vinegar.
 - Rinse the burette with the sodium hydroxide solution.

Question 3. A permanent pink colour will appear at the end point.

Question 4 $c(\text{CH}_3\text{COOH}) = \frac{6}{60} = 0.1 \text{ mole L}^{-1}$

In 20 mL $n(\text{CH}_3\text{COOH}) = \frac{0.1 \times 20}{1000} = 0.002 \text{ mol.}$

$$n(\text{NaOH}) = n(\text{CH}_3\text{COOH}) = 0.002 \text{ mol}$$

$$c(\text{NaOH}) = \frac{0.002}{0.002} = 1.0 \text{ M}$$

Question 5

- c) Because sodium hydroxide absorbs water and carbon dioxide from the atmosphere. Sodium hydroxide is thus not suitable as a primary standard.
- d) A solution of sodium hydroxide can be standardised by titration against a standardised solution of hydrochloric acid. The hydrochloric acid can be standardised by titration against a solution of sodium carbonate which has been prepared by dissolving and accurately weighed sample of anhydrous sodium carbonate into an accurately measured volume of distilled water.

Question 6 Refer to: 14 Experiment. Determination of the ethanoic concentration of vinegar.

Question 7. Random errors associated with measuring volume
Systematic errors. eg. The concentration of NaOH is incorrect or if the end point is not correctly identified.

29 Exercise: Analysis of proteins by thin layer chromatography – data analysis

Question 1 Refer to Fig 6.2 in Chemistry Two

Question 2 As the components of the mixture move over the stationary phase they undergo adsorption onto the surface of the solid and desorption back in to the liquid mobile phase. Each component adsorbs and desorbs to a different degree and hence moves along the stationary phase at a different rate. The components will therefore separate.

Question 3 [Refer to artwork brief](#)

Question 4 Using one solvent will not clearly separate all the amino acids particularly amino acids A & B and F & G
A second solvent running at right angles to the first will separate these amino acids.

Question 5 A & B and F & G

Question 6 a & b

Sample	R _f Value	
	Solvent A	Solvent B
A	0.00	0.24
B	0.00	0.35
C	0.20	0.27
D	0.40	0.38
E	0.50	0.49
F	0.60	0.60
G	0.60	0.69
H	0.70	0.80
I	0.34	0.71
J	0.80	0.31

Question 7

Sample	Amino Acid
A	Aspartic acid
B	Glutamic acid
C	Serine
D	Glycine
E	Alanine
F	Methionine
G	Valine
H	Isoleucine
I	β -alanine
J	Cysteine

30 Exercise: Ethanol content of wine by gas chromatography – data analysis.

Question 1 Ethanol has a lower retention time in the chromatography column. It is more soluble in the mobile phase (the carrier gas) and is not adsorbed as strongly onto the stationary phase.

Question 2 Both ethanol and propanol must be in the gaseous phase. At 60^oC both alkanols would still be liquids. Both will have vaporised at 110^oC.

Question 3

Sample	Conc. Of Ethanol (%)	Ratio peak areas ethanol: propanol
Standard 1	4.0	0.268
Standard 2	8.0	0.522

Note: This is an unedited, draft version. A fully checked, edited and formatted version will be available on the website <http://www.hi.com.au/chemistry/> in 2010

Standard 3	12.0	0.823
Standard 4	16.0	0.994
Diluted wine	Unknown	0.334

- Question 4 Refer to artwork brief
 Question 5 5.1%
 Question 6 10.2%
 Question 7 Some of the ethanol may have evaporated. If the bottle was left open long enough some of the alcohol could convert to acetic acid.

- Question 8 Refer to Fig 6.9 in the 4th edition of *Chemistry Two*
 Question 9 As the components of the mixture move over the stationary phase they undergo adsorption onto the surface of the solid and desorption back in to the liquid gaseous phase. Each component adsorbs and desorbs to a different degree and hence moves along the stationary phase at a different rate. The components thus have different retention times in the chromatography column.

33 Exercise: Determination of concentration of iron in breakfast cereal by atomic adsorption spectroscopy – data analysis

- Question 1 Refer to art work brief
 Question 2 Impurities in the water. Instrumental error. There is always background noise in any instrument and there may be a very small amount of Fe in the water depending on the quality of water used.
 Question 3 $6.7 \mu\text{g mL}^{-1}$
 Question 4 $6.7 \mu\text{g in 1 mL} = 670 \mu\text{g in 100ml} = 670 \mu\text{g in 10.0g sample}$
 Question 5 $670 \mu\text{g in 10.0 g} = 6700 \mu\text{g in 100.0g} = 6.7 \text{ mg in 100g}$
 Question 6 $\text{RDI} = \frac{6.7}{0.56} = 11.96 = 12 \text{ mg (2 sig figs)}$ 10.0g provides 6.70 mg.

Question 7 mass cereal that provides 12 mg = $\frac{6.70}{10.0} \times 12 = 8.0 \text{ g}$

- Question 8. The specific wavelength required to excite the electrons in the iron is 248.3 nm . The atoms absorb the radiation and the amount of energy absorbed is proportional to the amount of iron present in the sample.

- Question 9 Refer to diagram 7.13 in 4th Edition of *Chemistry Two*.

- Question 10 When a metal atom absorbs electromagnetic radiation electrons are promoted to a higher energy level. In atomic absorption spectroscopy the amount of light absorbed, which is dependent on the concentration, is measured.

34 Exercise: Concentrations of caffeine in a cola drink by UV -visible spectroscopy –data analysis

1. “m” represents the mass of caffeine in the 100 mL sample of cola drink
2. Refer to artwork brief
3. Refer to artwork brief
4. 8.0g caffeine in a 100 mL sample
5. 8.0 g caffeine per 100 mL = 100g per 1250 mL. This is less than the amount reported to cause the symptoms listed
6. Mass caffeine in 1L = $8.0 \times 10 = 80$ g

$$\text{No mole L}^{-1} = \frac{80}{194} = 0.041 \text{ M}$$
7. A wavelength of 275nm is chosen because the absorbance of caffeine in the UV/visible spectrum is very high at this wavelength. The absorbance of other substances that could be present are low at this wavelength.
8. Refer to Fig 7.15 in the 4th Edition of *Chemistry Two*
9. Electromagnetic radiation in the visible /UV part of the electromagnetic spectrum has sufficient energy to excite electrons from lower to higher energy levels. Different substances have different energy levels so the energy (or wavelength) of radiation required to promote electrons to higher energy levels vary.

35 Exercise: Analysis of organic compounds by IR Spectroscopy – data analysis

Question 1. Propan-2-ol CH, OH, CO
 Propanone CH, C=O

Question 2 Table 35.2 Propanone

Group	Wavelength range cm^{-1}
CH stretch	3000 - 2850
C=O stretch	1800 -1680

Table 35.3 Propan-2-ol

Group	Wavelength range cm^{-1}
CH stretch	3000 - 2850
C-O stretch	1240-1070
O-H stretch	3600-3200

Question 3.

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	Peak A	Peak B
Spectrum Fig 35.2	OH	C-H
Spectrum Fig 35.3	C-H	C=O

Question 4. Spectrum Fig 35.2 is propan-2-ol
Spectrum Fig 35.3 is propanone

36 Exercise: Interpretation of the nuclear magnetic resonance (nmr) spectra of a number of organic compounds– data analysis

Question 1

Group (with same H environment - shown in bold))	Relative abundance	Splitting
CH₃ CO	3	1
- CH₂ -	2	4
-CH ₂ - CH₃	3	3

Question 2.

Group (with same H environment shown in bold)	Relative abundance	Splitting
A -CHO	1	1
B CH₂-CH₂ -CHO	2	3
C CH₃-CH₂ -CH ₂	2	6
d CH₃ -CH ₂	3	3

Question 3

<i>Chemical shift(av)</i>	<i>Relative abundance</i>	<i>Splitting</i>	<i>Group</i>
2.5	2	4	CH₃-CH₂
2.1	3	1	OC-CH₃
1.1	3	3	CH₃ -CH ₂

Question 4 Butan-2-one

Question 5 a. butan-2-one 4 peaks
b. butanal 4 peaks

Question 6 The chemical shift for the signals would be different

Question 7 Magnitude of the chemical shift
Splitting in proton NMR

37 Exercise: Interpretation of the mass spectra of a number of organic compounds – data analysis

Question 1. The m/e of the parent molecular ion of 3-pentanol is 88

Question 2. The mass of the ion that forms the base peak is 59

Question 3. $C_5H_{12}O^+ \rightarrow C_3H_7O^+ + C_2H_5$ or
 $CH_3CH_2CHOHCH_2CH_3^+ \rightarrow CH_3CH_2CHOH^+ + CH_3CH_2$

Question 4. The mass of the uncharged fragment left when the base peak is formed is 29. The fragment also forms as an ion that appears on the mass spectrum

Question 5. $C_3H_7O^+ \rightarrow C_3H_5^+ + H_2O$
 The m/e of the ion that results is 41

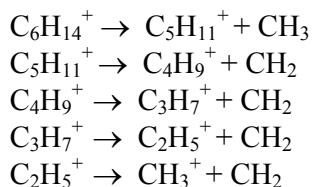
Question 6..

m/e	Possible structure
15	CH_3^+
29	$C_2H_5^+$ or CHO^+
32	CH_3O^+
41	$C_3H_5^+$
59	C_3H_7O

Question 7. The mass difference between the successive major peaks in the spectrum from m/e 71 downwards is 14.

Question 8. The fragment is CH_2

Question 9..



Question 10.

m/e	Possible structure
88	$C_4H_8O_2^+$
45	$CH_3CH_2O^+$
43	CH_3CO^+
29	$CH_3CH_2^+$

Question 11. The formula of the uncharged fragment is OH

Exercise 38: Submission for an analytical instrument

The following may need to be considered

- Nature of the analyte
- Size of sample
- Time required to conduct analysis
- Cost of equipment and reagents
- Level of expertise requires to conduct analysis
- Quality and precision of data required.

Further information about the functioning and use of various analytical instruments may be found in chapters 1-8 in Chemistry Two, 4th edition.

The Heinemann website, <http://www//hi.com.au>, has a power point template that may be useful for this exercise.

39 Exercise: Study of an analytical instrument

Chapters 6,7 & 8 in Chemistry Two, 4th Edition contains information related to this exercise

41 Exercise: Modeling and naming alkanes

Part A Straight chain alkanes.

Question 1 Only pair (iv) are isomers. It is the same substance in all other pairs.

Question 2 a) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_2\text{CH}_3)\text{CH}_2\text{CH}_3$

b) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_3$

Question 3 a) 3-methylhexane

b) 3-methylpentane

c) 4-ethylheptane

57 Exercise: The therapeutic revolution.

Heinemann Chemistry Two, 4th Edition, contains two cutting articles that may be useful. They are: Computer Aided Drug Design, p 226, and

Designer Medicines: Molecules of the Future, p 236